Exploring Forecast Sensitivity through an Ensemble of Varying Land Surface Parameterizations, Soil Moisture, and Vegetation Characteristics

[1]Andrew Molthan, [2]Jonathan Case, [3]Jayanthi Srikishen, and [1]Bradley Zavodsky

[1]NASA Short-term Prediction Research and Transition (SPoRT) Center, NASA MSFC, Huntsville, Alabama, [2]ENSCO, Inc./NASA SPoRT Center, Huntsville, Alabama

[3]Universities Space Research Association/NASA SPoRT Center, Huntsville, Alabama

andrew.molthan@nasa.gov

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Background and Motivation

- The NASA Severe Thunderstorm Observations and Regional Modeling (NASA STORM) project included a component exploring the impact of land surface modeling and parameterizations on convection-allowing regional models.
- Here, we provide some highlights of case studies performed with a small ensemble of regional models focused on differences in land surface properties versus a control configuration.
- Efforts focused on whether additional land surface detail would provide additional information for the simulated events.
- Team also wanted to understand the time requirements for trying to produce a near real-time ensemble focused on land surface characteristics in response to predicted severe weather.

Ensemble Configuration

- 6 of the 20 member GEFS ensemble, randomly selected.
- 3 configurations for each GEFS ensemble member, varying the land surface, totaling 18 different model runs.
- Ensemble membership focused on changes in the land surface conditions and physics configurations:
- Land surface conditions derived exclusively from the GEFS initial and boundary conditions
  - GEFS land surface replaced with NASA Land Information System (LIS) but retaining climatological vegetation fraction
  - GEFS land surface replaced with NASA LIS and near real-time NOAA/NESDIS VIIRS Green Vegetation Fraction (GVF)
  - 6 default GEFS, 6 GEFS + LIS, 6 GEFS + LIS + VIIRS
  - 3 km spatial resolution, 56 levels, 18 second time step.
- All simulations predict the evolution of storms with the Goddard 4-ice microphysics and radiation physics, MYJ PBL, and Noah LSM.

Simulated Events

- Simulations focused on a springtime event supporting classic supercells and a summertime northwest flow event, each producing severe weather across the forecast domain (Figure 1).

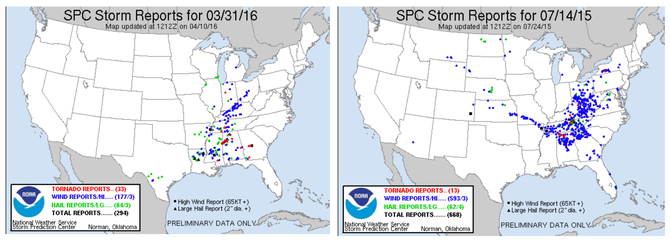

Figure 1. Storm Prediction Center severe weather reports for a supercell event in northern Alabama on 31 March 2016 (left) and severe thunderstorms that evolved during a strong northwesterly flow event on 14 July 2015 (right).

Variability in Land Surface Conditions

- Two cases were selected to examine forecast sensitivity to initial conditions, in land surface (Figure 2) and soil moisture (Figure 3).
  - For the spring (supercell) case of March 2016, default GEFS land surface is greener than observed by VIIRS, by as much as 10-20% in Central Alabama (Figure 2).
  - During the summer (northwest flow) case of July 2015, VIIRS observations are much greener than the GEFS, with observations 10-20% higher (Figure 2).

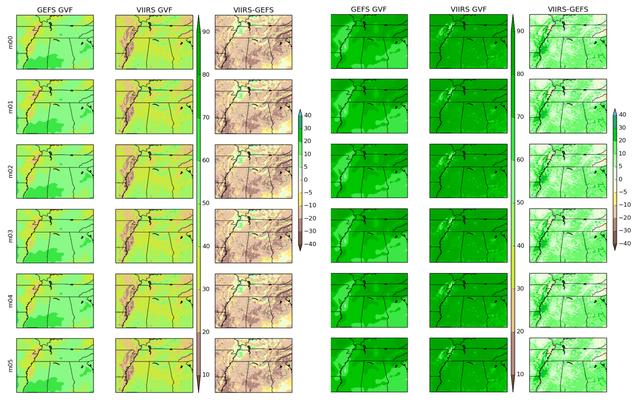

Figure 2. Green vegetation fraction (GVF) of the GEFS members (left column), near real-time GVF from VIIRS (center), and difference (right) for the two events: supercells of 31 March (left series) and northwest flow on 14 July (right series).

- In both events, the NASA Land Information System (LIS) soil moisture was drier throughout much of the domain, particularly across Alabama with the exception of the Black Belt (Figure 3).

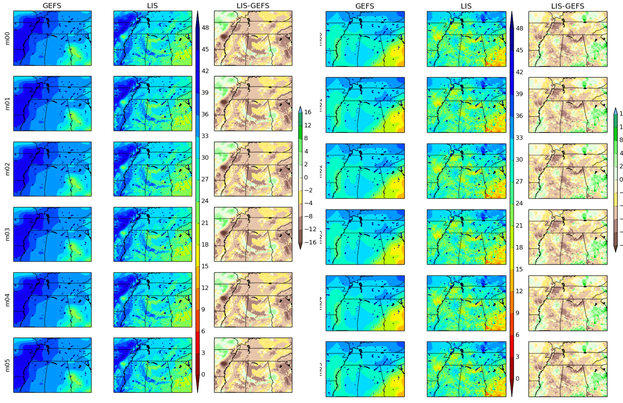

Figure 3. As in Figure 1, but focused on 0-10 cm (near surface) soil moisture among the GEFS, NASA LIS, and difference fields for both severe weather events.

Linear Segments and Supercells: 31 March 2016

- Differences in the land surface contribution to each member were much smaller than differences in the GEFS initial and boundary conditions. Environment favored linear and bowing segments with embedded supercells (Figure 4).
- Relatively minor differences in ensemble members attributable to differences in soil moisture or vegetation and storm distributions common across GEFS members.

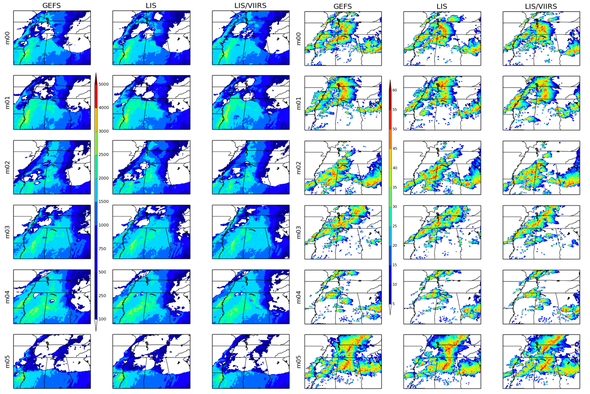

Figure 4. (left) 24-hour forecast of surface-based CAPE for ensemble members in valid at 00UTC on 1 April. (right) Composite radar reflectivity with storm distribution and mode similar for the same GEFS initial and boundary conditions.

Summertime Northwest Flow: 14 July 2015

- Inclusion of the LIS soil moisture fields and VIIRS GVFs contribute to warmer and drier conditions (Figure 5) with overall reduction in SBCAPE (not shown) in central Alabama.

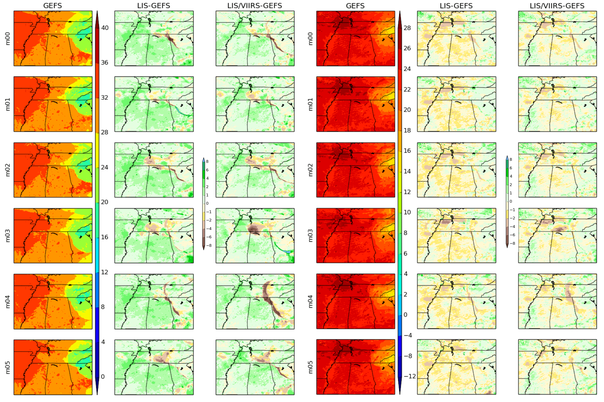

Figure 5. (left) 24-hour forecast of 2 m temperature and (right) dew point, along with differences versus GEFS initial conditions, valid 00 UTC on 15 July 2015.

Summertime Northwest Flow: 14 July 2015

- Despite warming and drying by surface fields and reduction in CAPE, LIS and LIS/VIIRS GVF members provided earlier initialization along back-building line of severe thunderstorms (Figures 6 and 7).
- Subjective, this was an improved fit to observations that included severe weather and tornadoes from 21-00 UTC in North Alabama.

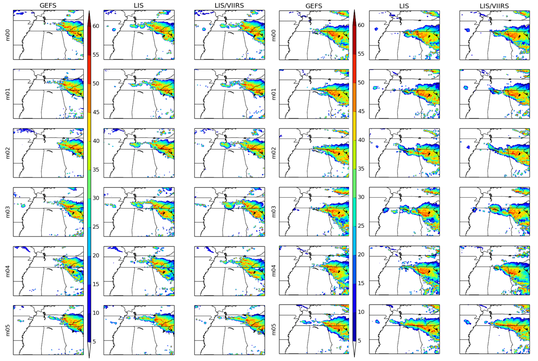

Figure 6. (left) 21-hour forecast of composite radar reflectivity for various members, and (right) 24-hour forecast of the same parameter, capturing additional back-building of storms across North Alabama.

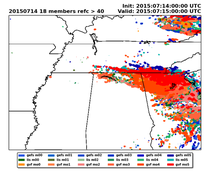

Figure 7. Paintball graphic highlighting locations where various model ensemble members predicted at least 40 dBZ of composite reflectivity, color-coded by ensemble member type. Additional backbuilding by LIS (green), and GVF (red) members is shown in northern Alabama.

Summary and Future Work

- A small regional ensemble was established over the southeastern United States to explore the impact of higher resolution soil moisture and vegetation information from the NASA LIS and NOAA/NESDIS VIIRS GVF products.
- Two events were explored, a strongly forced springtime event where land surface parameters had minimal impact, and a northwest flow event in mid-summer, where warming and drying by LIS and GVFs contributed to differences in storm evolution.
- Future work will explore the feasibility of a similar, small ensemble system for near real-time events with a focus on the southeastern United States.